The Impact of Nonequilibrium Ionization on SDO/AIA and Hinode/EIS Observations of Impulsively Heated Plasmas

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Most plasma diagnostics assume the emitting material is in a state of ionization equilibrium. For example, the AIA temperature response functions have been derived on this basis. The assumption is reasonable whenever the plasma is evolving slowly or is very dense, but these are not the conditions that apply during impulsive heating events. It is now widely believed that many coronal loops are bundles of unresolved strands that are heated quasi-randomly by nanoflares. Full blown flares are thought to have similar sub-structure. We have studied the importance of nonequilibrium effects in these circumstances by modeling nanoflare-heated loops and simulating their observation by AIA and the EIS spectrometer on Hinode. We find that the intensities of hot emission lines can be highly suppressed and that the net emission from the loop tends to be dominated by strands that have entered a slow cooling phase, well after the impulsive energy release has ended. The hottest strands are relatively invisible, both because they are tenuous and because they cool rapidly by thermal conduction. Thus, AIA channels that are normally thought of as being sensitive to hot plasma, such 131 and 94, are in fact frequently not able to detect the hot plasma that is present. The magnitude of the effect is case dependent. Great care must be exercised when using the standard temperature response functions in situations where nonequilibrium ionization is likely to be important.